

Summary information on insulation

Key Environmental and Performance Factors for Insulation Materials

Insulation Type	R-value Per Inch*	Estimated Installed Cost Per ft ² for R-19**		Vapor Permeability†	Air Barrier‡	Environmental Notes (see below for legend)
		Low end	High end			
FIBER, CELLULOSIC, AND GRANULAR						
Fiberglass	Batt	3.3	\$1.00	\$1.88	Class III: Semi-Permeable	Not an air barrier—batts especially susceptible to air infiltration    Avoid formaldehyde binders
	Blown-in	3.8	\$1.00	\$1.50		
	Spray-applied	3.7–4.2	\$0.90	\$1.50		
Cellulose	Spray-applied	3.8–3.9	\$0.93	\$1.79	Class III: Semi-Permeable	Not an air barrier, but dense-packed cellulose enhances air resistance of an assembly   
	Loose fill	3.6–3.7	\$0.73	\$1.25		
Mineral wool	3.3	\$1.44	\$2.10	Class III: Semi-Permeable	Not an air barrier    Choose low-emitting products	
Cotton	3.4	\$2.16	\$3.60	Class III: Semi-Permeable	Not an air barrier    Shipping energy may be significant	
Polyester	3.7	Product not currently available		Class III: Semi-Permeable	Not an air barrier   	

Summary information on insulation

Extruded polystyrene (XPS)	4.8–5	\$3.75	\$4.37	Class II: Semi-Permeable (>1") Class III (<1")	Air barrier material	    High global warming potential for urethane-core SIPs Brominated flame retardant (otherwise fairly inert) Toxic manufacturing process
Expanded polystyrene (EPS)	3.7–4.5	\$3.00	\$4.32	Class II Vapor Retarder	Not an air barrier	   Brominated flame retardant
Mineral wool	2.4–3.3	\$2.15		Class III Vapor Retarder	Not an air barrier	   Choose low-emitting products
Fiberglass	3.6–4.5	\$1.85	\$4.72	Class III Vapor Retarder	Not an air barrier	   Formaldehyde binders are common

About the Environmental Notes

-  Green indicates significant **recycled content** or renewable material. Red indicates little or no recycled content and fossil-fuel-based materials in typical products.
-  Green indicates low **embodied energy**. Red indicates high embodied energy and/or embodied carbon.
-  Green indicates relatively low **toxic emissions** during use from typical products. Red indicates potential high toxic emissions from typical products.

 Red indicates high toxic emissions during manufacturing or application.

Blue in all cases indicates ambiguity—explanatory notes are provided in all cases.

Notes are provided for red indications in some cases.

Please see page 85 for endnotes.

Bottom-line BuildingGreen Recommendations

Bottom-Line Insulation Material Recommendations cont.

Recommended Insulation Materials	Environmental Issues	Performance and Cost Issues
COMMERCIAL CAVITY FILL		
See note above on similar considerations relevant to residential cavity fill. Also note that due to fire codes and other considerations in commercial construction, our recommendations here are somewhat different.		
<p>✓ BuildingGreen Top Pick Spray-applied or dense-packed fiberglass</p>	JM Spider from Johns Manville has 30% recycled content. Higher embodied energy than cellulose. Fire-resistant without flame retardants.	Impedes air leakage, not susceptible to moisture. Installation in an open cavity may be possible without netting. "Blow-in-Blanket" systems require netting on the interior faces of framing members.
Mineral-wool batts	Higher recycled content than fiberglass but higher embodied energy than cellulose and potential formaldehyde emissions.	Compared to spray-applied fiberglass, greater potential for gaps and poor installation; follow manufacturer guidelines.
Dense-packed cellulose	Higher recycled content and lower embodied energy than fiberglass.	Recommended for wall cavities with good moisture management and drying potential in at least one direction.
EXTERIOR INSULATING SHEATHING		
Exterior insulation should be thick enough to maintain the dew point within the material (recommended thickness depends on climate and other factors). Note that the products recommended here have different vapor permeability: polyiso is impermeable if foil-faced, and mineral wool may be impermeable depending on the facing. Design assemblies appropriately for moisture management (see page 26).		
<p>✓ BuildingGreen Top Pick High-density rigid mineral wool</p>	Available with high recycled content. Excellent sound control; insect- and moisture-resistant; some concern about formaldehyde emissions.	Available faced or unfaced. Can be difficult to source and requires tricky detailing for many types of siding.

Bottom-line recommendation: Commercial cavity-fill



Cavity-fill: spray fiberglass (Johns Manville Spider) - photos: Alex Wilson

Bottom-line recommendation: Exterior wall sheathing



Rigid mineral wool as exterior wrap, including insect screening - photos: Alex Wilson

Bottom-line BuildingGreen Recommendations

Recommended Insulation Materials	Environmental Issues	Performance and Cost Issues
RESIDENTIAL CAVITY FILL None of the following recommended products are air barriers; include a continuous air barrier separately from the insulation with all cavity-fill insulation options. All of the following products are vapor-permeable, although hygroscopic properties differ considerably. Insulation choices may be affected by the cavity design, framing materials, and other factors.		
✓ BuildingGreen Top Pick Dense-packed cellulose	Low embodied energy and carbon. Renewable, high recycled content. Flame retardant toxicity not a big concern.	Fills cavities completely, impedes air leakage. Settling is not a factor with dense-packing. Hygroscopic: can help manage moisture by seasonally absorbing and releasing water vapor as long as at least one side of the assembly is vapor-permeable, and as long as the wetting rate does not exceed the drying rate on an annual basis.
Spray-applied or dense-packed fiberglass	Higher embodied energy than cellulose. Not a renewable material.	Fills cavities completely, impedes air leakage at higher densities.
Mineral wool batts	Higher embodied energy than cellulose. Some emissions concerns from formaldehyde-based binder.	Use when greater fire rating is desired or as a superior option (compared to fiberglass batts) for small jobs. Can be hard to source.
Air-Krete, cotton batts, or dense-packed wool	Use when the owner has unique air quality concerns about other options.	More expensive than other options and harder to source. Specific performance downsides by insulation type: see body of report.
Fiberglass batts	Higher embodied energy; often poorly installed (see performance issues).	Difficult to install well (requires time to cut carefully around irregularities). Use only for budget-conscious jobs too small for an insulation contractor and where mineral wool batts are not available.

Bottom-line recommendation: Residential cavity-fill



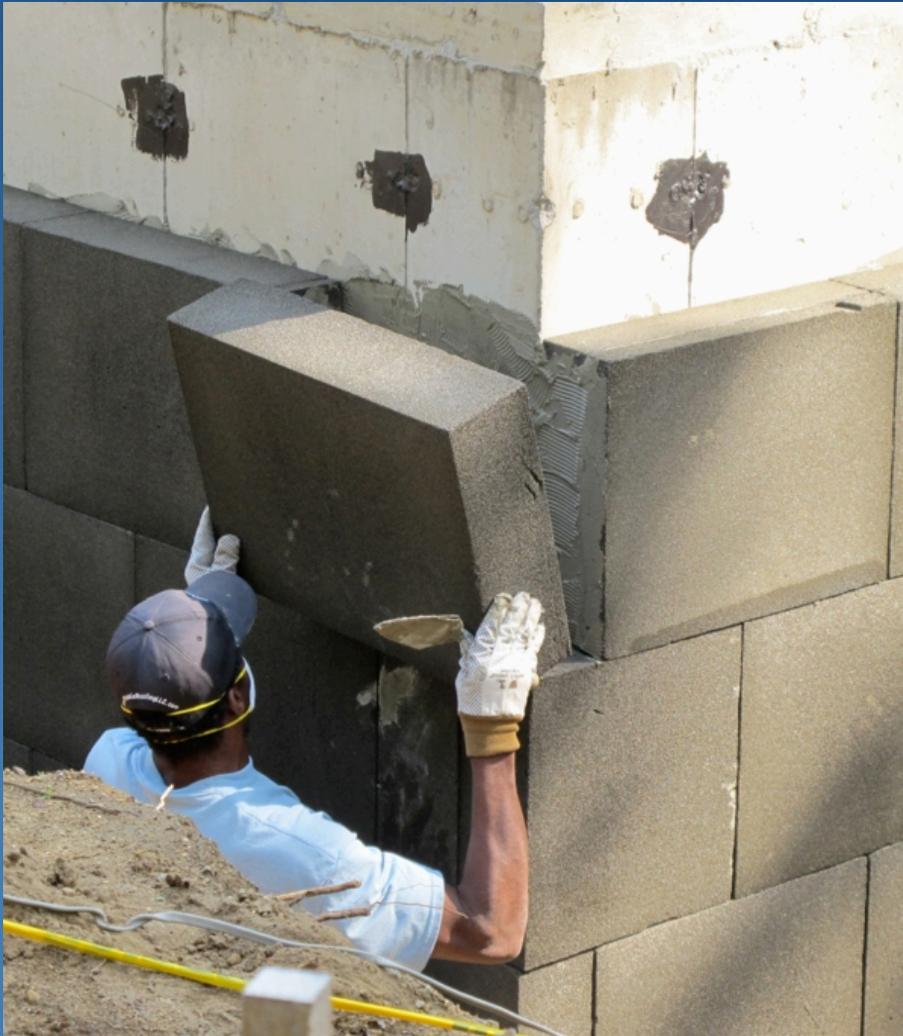
Damp-spray cellulose installation - photos: EnerSol

Bottom-line BuildingGreen Recommendations

Bottom-Line Insulation Material Recommendations cont.

Recommended Insulation Materials	Environmental Issues	Performance and Cost Issues
EXTERIOR FOUNDATION WALL		
✓ BuildingGreen Top Pick High-density rigid mineral wool	Hydrophobic, so it provides an excellent drainage layer.	Harder to install and cover than more common options. Sourcing may be a challenge.
Cellular glass (FoamGlas)	High compressive strength, impermeable to moisture, no blowing agents or flame retardants.	High cost—use if budget permits. Special installation required, including protection during backfilling and exterior protective coating. Follow manufacturer's instructions.
Expanded polystyrene (EPS)	Contains HBCD flame retardant. Don't confuse with extruded polystyrene (XPS), which we recommend against because of high global warming potential.	Use if rigid mineral wool is unavailable or there is strong resistance to its use. Specify higher-density EPS than standard. Type II or Type IX is recommended.
INTERIOR FOUNDATION WALL		
✓ BuildingGreen Top Pick Polyisocyanurate	Relatively high embodied energy, but blowing agents with high global warming potential (GWP) have been eliminated. Contains flame retardant.	Use on poured concrete and CMU walls that provide a relatively flat surface. After one layer of foam board, adding a stud wall with mineral wool or fiberglass is recommended for added insulation depth.
Phenolic Foam	No flame retardant; some concern about formaldehyde emissions.	Highest R-value of non-vacuum boardstock insulation materials. On foil-faced products, benefit of radiant barrier if installed with strapping.

Bottom-line recommendation: Below-grade foundation walls and sub-slab



Foamglas (this was top recommendation, now #2 after rigid mineral wool) - photos: Alex Wilson

Bottom-line recommendation: Below-grade foundation walls and sub-slab



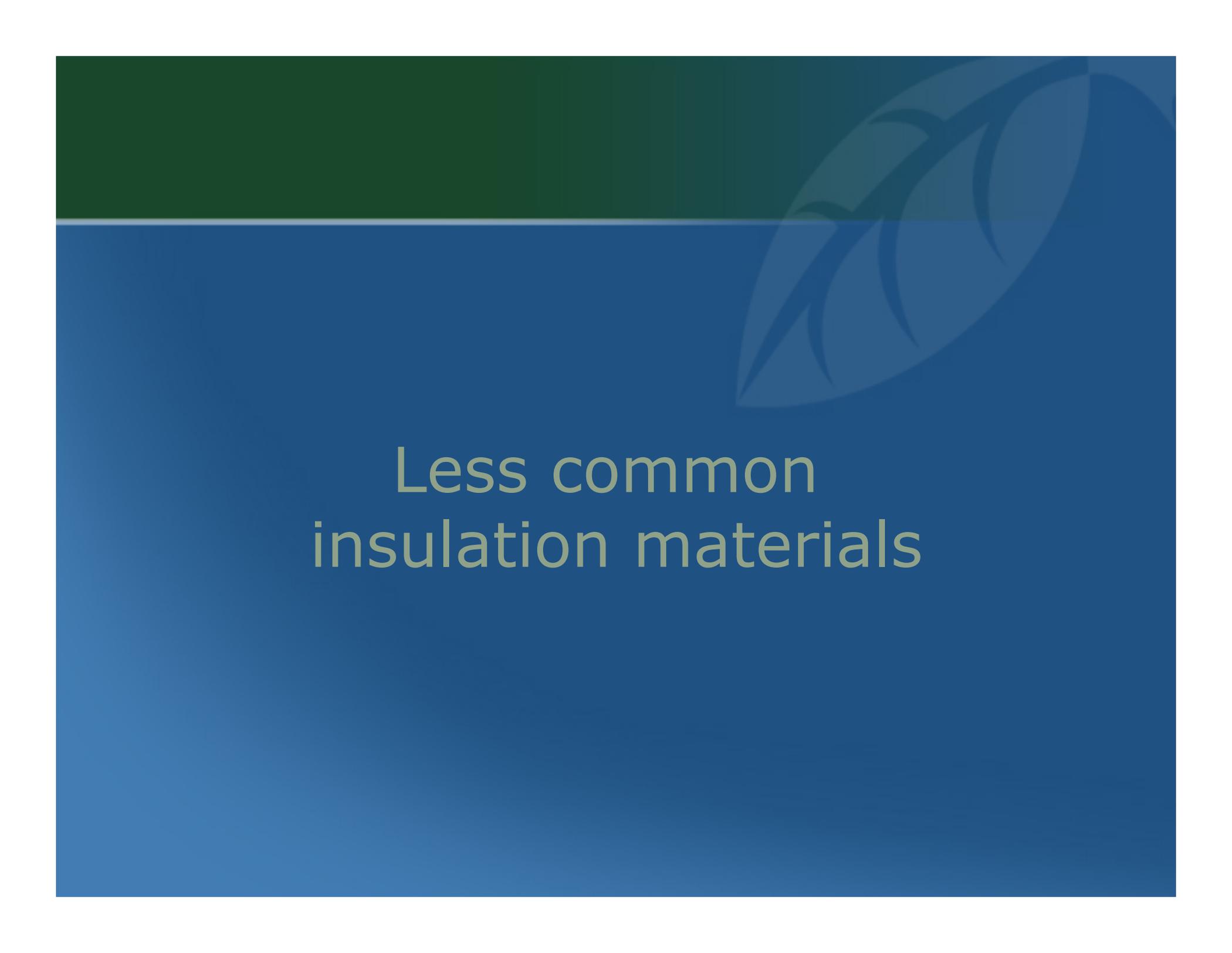
*Rigid mineral wool installation in the Vancouver area –
photo: Roxul*

- Rigid mineral wool
- Up to 8 pcf density
- Mainly used for roofs, but recent applications beneath slabs
- Zero GWP
- Should be cost-competitive with XPS
- Not as available

Recommended insulation for LEED v.4 and Living Building Challenge projects

Insulation Materials Under LEED v4 and the Living Building Challenge

Insulation type	LEED v4: Building product disclosure and optimization – environmental product declarations	LEED v4: Building product disclosure and optimization – sourcing of raw materials	LEED v4: Building product disclosure and optimization – materials ingredients	Living Building Challenge Red List
Fiberglass	Some products have an EPD.	Most fiberglass products contain 40%–60% recycled content.	Some products have a Declare label or HPD.	Fiberglass has historically contained formaldehyde but it has been mostly phased out of batts, and many rigid board products. Some products are LBC Compliant.
Cellulose	Some products have an EPD.	Most cellulose products contain 80% or more recycled content.	Some products have a Declare label or HPD.	Some products are Declare Red List Free, and this product type is unlikely to include red-list chemicals anyway.
Mineral wool	Has industry-wide EPD.	Most slag wool products contain 10%–15% recycled content, Most rock wool products contain 70%–90% recycled content.	Some products have a Declare label.	Many rigid mineral wool products contain formaldehyde, but LBC currently offers an exception for this in mineral wool insulation in exterior applications. Some products are Declare Red List Free.
Cotton	Does not meet relevant criteria.	Cotton products are likely to contain recycled material. Though currently there are no products meeting the SAN Standard for biobased products this may change in the future.	Does not meet relevant criteria.	Check with your manufacturer, but cotton insulation products are unlikely to contain red-list chemicals.



Less common insulation materials

Wood fiber insulation – rigid T&G boardstock



Gutex Thermowall – 70 mm - Photo: Gutex

Wood fiber insulation – flexible batts



Gutex Thermoflex – 240 mm
Photo: Gutex